RESPIRATORY SYSTEM[1]

I. INTRODUCTION

A. OUTLINE OF HIGHLIGHTED CONDITIONS

1) Obstructive Disease

2) Restrictive Disease

3) Miscellaneous Conditions

B. IMPLICATIONS FOR JOB PERFORMANCE

A pulmonary limitation to exercise may cause serious injury to both the patrol officer and the public in the following situations:

- Running in pursuit of suspects: speed is important in up to 90% of incidents, distances may range up to 500 yards.
- Pursuit followed by physical altercation: subduing combative subjects takes an average of 3 minutes.
- Moving incapacitated persons: ability to lift and carry someone distances of 40+ feet when speed is critical.

The minimum exercise capacity required to perform these tasks can be estimated from published tables of oxygen consumption (Jette, et al., 1990; AMA Committee on Exercise, 1972). These indicate that oxygen consumption at a level of approximately 42 ml O_2/kg/min is necessary to perform activities such as wrestling, running, and extensive lifting at a level of moderate-to-heavy intensity. Since oxygen consumption in a life-or-death struggle certainly could be much greater than 42 ml O_2/kg/min, this value represents a valid minimal level of fitness. Furthermore, this value is reasonable in that it represents the average fitness level of the most common group of arrestees, males <30 years old (Pollock & Schmidt, 1980).

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Depending on the location of the hiring agency, the physician also must consider that the above situations may occur during adverse environmental conditions such as:

- High levels of dust, pollutants, or other allergens;
- Cold air;
- High altitude (low oxygen);
- Exposure to toxic substances: This may occur when officers investigate clandestine drug labs or become first responders at toxic spills or fires. Some officers carry mace, which is an upper airways irritant.

II. MEDICAL EXAMINATION AND EVALUATION GUIDELINES

A. GENERAL SCREENING RECOMMENDATIONS

1) History: See Medical History Statement.

2) Examination: All candidates should have a standard auscultatory exam.

3) Routine Testing: A spirogram is highly recommended for all candidates to ensure the veracity of the reported medical history.

In performing the spirogram, attention to detail is important. All technicians must be trained in the proper calibration and administration of the test as specified in the spirometry standards of the American Thoracic Society (Gardner, 1979). To assure reliability, it is recommended that at least three efforts be recorded, and that the FEV1 and FVC values of the best two efforts be within 5% of each other.

The physician should be skilled in the interpretation of spirograms; therefore, a review of a text or articles on this subject is highly recommended (Enright & Hyatt, 1987; Hankinson, 1986). The following considerations deserve special emphasis:

- Caution must be taken to ensure that predicted values are based on correct age, height, and race data before decisions are made. All candidates except for African-Americans should be entered as "Caucasians." If the spirogram does not correct for race, the predicted volumes for African-Americans should be lowered by 10-15%. At the present time, Latinos and Asians are entered as Caucasians. However, the physician should keep in mind that several studies indicate that these groups have predicted values somewhere between African-Americans and Caucasians.

- To both interpret the spirogram and assess compliance, it is helpful to know if the candidate used any medication on the day of the test. A serum level of theophylline on the day of testing is recommended if the candidate has any history of theophylline use.

- Values for the FVC and FEV1 of 80% predicted and an FEV1/FVC ratio of 70% are generally considered to be at the lower end of the normal range. If these volumes are normal, spirometry parameters which measure low-volume flow rates (FEF 25-75, FEF 75) may still indicate small airways obstruction, especially in smokers. However, these measurements have no established relationship to functional exercise capacity and are very unreliable.

- If volumes are below normal, it is important to inquire about respiratory infections over the last six weeks, since these can cause lingering abnormalities.

4) Supplemental Testing Procedures

a. Chest radiographs: These may have some benefit in routine screening of older candidates who have a history of smoking or exposure to asbestos. Otherwise, their use as a routine screening tool in healthy adults has an extremely low yield, and therefore is not recommended. However, the chest radiograph may provide important information in candidates who have chronic pulmonary symptoms without a specific diagnosis or those with restrictive patterns on a screening spirogram.

b. Exercise stress testing (EST): Routine ESTs to assess a potential pulmonary limitation to exercise are not necessary in candidates with no history of pulmonary disease or abnormal spirometry. However, when a pulmonary limitation to exercise is suspected, an EST is an important ancillary tool to help the physician assess the applicant's maximal aerobic capacity.

The gold standard is a complete "pulmonary" EST, which includes continuous measurement of expired-air gas concentrations (Jones, et al., 1988). This test will accurately determine exercise capacity, as well as distinguish between cardiac and pulmonary limitations to exercise. Unfortunately, it is invasive, expensive, and generally only performed by pulmonary specialists.

There are several alternative tests that can be performed; however, while these will not allow differentiation between pulmonary and cardiac limitations to exercise, this is not a significant shortcoming, since the primary purpose of exercise testing of candidates with pulmonary disease is to assess maximum functional capacity, rather than to establish a specific diagnosis.

1. EST with measurement of expired gases: This test has the advantage of direct and accurate measurement of oxygen consumption. Various protocols with treadmills or bicycle ergometers can be used. The main disadvantages are limited availability and cost.

2. Cardiac stress testing: This test is the least expensive and most readily available, but maximum oxygen consumption cannot be measured directly. However, it does correlate highly with duration of exercise (r = .90) if a standard Bruce protocol is used (AMA Committee on Exercise, 1972). Therefore, maximum oxygen consumption may be estimated as follows:

   VO_2 MAX = 2.94 (minutes) + 7.65 for men, or
   2.94 (minutes) + 3.74 for women

   Sources of error which could cause an underestimation of oxygen consumption include obesity and static muscle tension from gripping of siderails. Therefore, candidates who have low exercise capacity should be given the option of obtaining more accurate testing.

3. Field tests: There are a variety of protocols for estimating VO_2 MAX involving timed walking, running, stepping, or bicycling. Some of these tests are as accurate as cardiac stress testing; however, prediction equations vary depending on the age and sex of the population tested. Therefore, the selection of an appropriate field test and prediction equation must be based on the age and sex of the candidate. An excellent review article on the subject was published by Kline, et al. (1987).

c. Methacholine testing: The degree of bronchial responsiveness can be estimated by the administration of a provoking agent, followed by objective measurement of airways obstruction. Methacholine is currently considered the standard provoking agent. Test results are expressed as the minimum concentration necessary to cause a 20% reduction in the FEV1 (PC20). Clinical uses include:

1. Validation of hyper-responsiveness when spirometry is normal;

2. Quantification of severity: Generally, a PC20>20mg/cc is not associated with symptomatic disease. Conversely, a PC20<2mg/cc is frequently associated with symptomatic bronchospasm (Giudice, 1989);

3. Estimation of amount of treatment required; and

4. Measurement of change in responsiveness in order to optimize treatment or to diagnose occupational asthma.

Although, theoretically, this test is very attractive, it has major limitations due to its low sensitivity and specificity (Weiss, 1990). Moreover, the test does not reliably predict 2-3 year prognosis or identify which candidates may develop airways reaction after unprotected chemical exposure. Therefore, for the purposes of assessing patrol officers with asthma, the test must be used cautiously and only in the context of other relevant factors.

B. EVALUATION OF COMMON CLINICAL SYNDROMES

1) OBSTRUCTIVE DISEASE

Candidates with a history of asthma or exercise-induced bronchospasm (EIB) require special consideration. Similarly, the physician must evaluate those who deny a positive history but demonstrate an obstructive pattern on a screening spirogram (FEV1/FVC ratio <70%).

a. GENERAL CONSIDERATIONS:

Obstructive disease can be categorized into two general classes:

- Fixed air flow obstruction:

  Conditions such as emphysema and chronic bronchitis are characterized by a fixed and relatively non-variable degree of air-flow obstruction. Unless there is an intercurrent infection, measurements of lung volumes on a given day are a reliable predictor of volumes on random days. Similarly, lung volumes are only minimally improved with medication, and exercise-induced bronchospasm (EIB) is not common.

  The major consideration in these candidates is their exercise capacity.

- Variable air flow obstruction:

  Asthma is characterized by large variability in lung volumes and clinical symptoms. On any given day, flow rates and volumes reflect combined influences of a multitude of factors such as compliance with medications, atmospheric conditions, exposure to allergens, air pollutant concentrations, and the recency of aerobic exercise. Thus, an in-depth individualized assessment, that includes testing on multiple days and record review, is essential before these candidates are allowed to perform patrol officer duties without restriction.

  Evaluation of these candidates is further complicated by consideration of EIB and medication use:

  Exercise-induced Bronchospasm: EIB commonly occurs in candidates with a known history of asthma and in others who may deny asthma, but who have a history of allergies. EIB can develop either during or immediately after (commonly 5-20 minutes) a period of aerobic exertion, and lasts for at least five minutes. EIB tends to be greater with activities that cause high ventilation rates with cool and dry air. Therefore, running causes more EIB than swimming. Depending on its severity, EIB may limit exercise capacity, thus posing a direct threat to the officer and the public.

The clinical significance of EIB can be assessed by history and/or an EST with pre and post spirograms. Post-exercise spirograms should be conducted at 5, 10, and 20 minute intervals. A decrease in FEV1 of more than 10% compared to the baseline is abnormal (Jones, et al., 1988). However, clinical significance depends on the absolute value of the FEV1, auscultatory findings, and symptoms. The primary concern is whether the candidate could reinitiate and sustain an exercise level requiring 42 ml O_2/kg/min at the time of peak bronchoconstriction.

Use of medication: Individuals with asthma who use medication can be separated into two broad categories:

1. Candidates who require pre-exercise medication to prevent EIB: Patrol officers must be capable of maximal exertion without warning. Consequently, the use of pre-exercise medication cannot be accommodated.

2. Candidates who use only regularly scheduled medication with no p.r.n. use before or after exercise: In these cases, the candidate's past compliance with the prescribed medical regimen and the effectiveness of this regimen are the major determinants of fitness for duty.

b. RECOMMENDED EVALUATION PROTOCOL:

Candidates with a positive history of obstructive disease, EIB, or abnormal spirometry should be carefully interviewed. Specific inquiries should include:

- Has there been any interference with routine exercise/activities in the last two years due to this condition?

- What type, intensity, and duration of exercise causes EIB? Is pre-medication used?

- If medication use is denied, be sure to ask about OTCs or use of a "friend's inhaler."

- Do symptoms only occur with concurrent infections? If so, how often do these infections occur?

- Has the candidate had to obtain unscheduled medical evaluations in the past two years?

- Has the candidate's condition required an increase in the dosage or number of medications in the past two years?

Review of relevant medical and pharmacy records for the past two years is highly recommended.

GROUP I: OBSTRUCTIVE PATTERN ON SPIROGRAM BUT NEGATIVE HISTORY OF OBSTRUCTIVE DISEASE, EIB, OR MEDICATION USE IN THE LAST 10 YEARS

Level 1: FEV1/FVC 50-69%

These candidates should undergo an EST with pre/post spirograms. A recommendation for unrestricted duty should be based on a reliable history and the ability to complete an acceptable level of exercise without clinically significant EIB. Note: If the physician has reason to doubt a benign history in these candidates, a methacholine test could provide enough ancillary evidence to warrant further investigation by the hiring agency.

Level 2: FEV1/FVC <50%

It is highly probable that obstruction of this degree will prevent sustained pursuits or survival in a subsequent altercation. Therefore, restrict from these types of job duties.

GROUP II: ADMITS TO A POSITIVE HISTORY OF OBSTRUCTIVE DISEASE, EIB, OR MEDICATION USE IN LAST 10 YEARS

The physician should carefully assess the variability of the candidate's disease, and the need for pre/post-exercise medication during the past two years. Evidence consistent with clinically significant variability would include:

- Use of non-inhaled steroids;
- Need for unscheduled medical care for pulmonary symptoms;
- An increase in the dosage or the number of therapeutic drugs (Note: Substitution of one drug for another may be due to changes in prescribing practice rather than the candidate's condition);
- Impairment in occupational or recreational activities;
- More than minor symptoms;
- Variability in the measured FEV1 of >10% when the FEV1/FVC ratio is below 70%.

Level 1: Stable disease with no use of pre/post-exercise medication during the past two years

Obtain an EST with pre/post spirograms. In general, no restrictions are necessary if the candidate is able to complete an acceptable level of exercise without clinically significant EIB, and the physician believes that an acceptable level of functioning can be maintained during the vast majority of workdays within the next 2-3 years. For certain hiring agencies, the physician may have to consider whether the candidate will be able to maintain adequate functioning when exposed to severe environmental/toxic conditions.

Note: In borderline cases, the physician may consider obtaining a methacholine challenge test or requiring weekly spirometry for a period of time.

Level 2: Variable disease or need for pre/post-exercise medication during past two years

In general, EST testing is unreliable in these candidates. Clinically significant variability makes functional assessment on any given day unrepresentative. Similarly, due to the difficulty in detecting whether a candidate has surreptitiously used an inhaler before a scheduled EST, it is often not possible to reliably predict the severity of EIB in situations where intense and sustained exercise is required without warning. Given these limitations, the physician will have difficulty certifying that the candidate could sustain a pursuit or survive a subsequent altercation.

Note: Candidates who are restricted should be advised that they can be re-evaluated at a future time if their condition improves, either with or without medication. However, physicians should require that candidates demonstrate that any such improvement is not temporary. Special caution is needed if a candidate begins using regularly scheduled medications in lieu of p.r.n. pre-exercise treatment, since this regimen is more difficult and expensive for the candidate. Therefore, before recommending that these candidates may work without restrictions, the physician may want to confirm compliance by reviewing pharmacy records over a period of time. Moreover, without unnecessarily revealing the diagnosis to unauthorized individuals, the physician should advise the hiring agency that continued surveillance of pharmacy records is needed to ensure the candidate's fitness for work. The hiring agency may then wish to require the candidate to sign a pre-employment accommodation contract which gives the physician periodic access to pharmacy records.

2) RESTRICTIVE DISEASE

a. GENERAL CONSIDERATIONS:

Physicians should give special consideration to candidates with a history of a connective tissue disease, interstitial lung disease, scoliosis, or chest wall abnormality capable of causing a restrictive pulmonary defect. The physician should also evaluate those who deny a positive history, but who demonstrate a restrictive pattern on a screening spirogram (FVC <80% predicted with normal FEV1/FVC ratio).

Fortunately, the prevalence of restrictive disease is low. However, technical errors which can cause minor underestimations of the FVC are common. If the history is negative, the physician should carefully inspect all restrictive spirograms for the following before recommending further evaluation:

- Does the tracing show smooth curves with reproducible measurements of the FVC?
- Do volume-time curves plateau for at least one second at the end of the effort?
- Is the predicted FVC volume based on the correct age, height, and race data?

b. RECOMMENDED EVALUATION PROTOCOL:

GROUP I: FVC <80% PREDICTED DUE TO OBVIOUS CHEST WALL ABNORMALITY

Obtain an EST to assess exercise capacity. If acceptable, see Musculoskeletal chapter.

GROUP II: FVC <80% PREDICTED, POSITIVE HISTORY, OR POSITIVE PHYSICAL EXAM THAT IS NOT DUE TO OBVIOUS CHEST WALL ABNORMALITY

Request an evaluation by a pulmonologist that includes a chest radiograph and complete pulmonary function testing to measure total lung capacity and diffusion capacity.

Level 1: Normal vital capacity, diffusing capacity, and chest radiograph

Capable of full duty, no work restrictions necessary.

Level 2: No evidence of interstitial disease since diffusing capacity and chest radiograph are normal, but restrictive pattern confirmed by low vital capacity

Request an EST that includes expired gas analysis and oximetry. A full duty recommendation should be based on the attainment of an oxygen consumption level of at least 42 ml O_2/kg/min without oxygen saturation falling below 90%. The latter would indicate inadequate oxygenation of the tissues which would impair sustained efforts.

Level 3: Specific disease diagnosed

Base final recommendation on an assessment of current functional ability (see Level 2), consideration of the 2-3 year prognosis for significant progression, and the clinical significance of non-pulmonary manifestations.

3) MISCELLANEOUS CONDITIONS

There are many other less common respiratory conditions that require special evaluation. These conditions require careful consideration of the nature, severity, duration, and likelihood of impairment associated with the condition and the demands and conditions of the job. The example below involving spontaneous pneumothorax, is intended to illustrate ways in which job-related issues should be considered when determining a candidate's ability to perform the essential duties of the job.

a. GENERAL CONSIDERATIONS:

Spontaneous pneumothorax (SP) can cause sudden or insidious impairment. Sudden chest pain and dyspnea have been found to occur in 85% of cases (Klassen & Meckstroth, 1962); total incapacitation has been found in 18% of cases (Voge & Anthracite, 1986). Moderate to severe distress is apparent in approximately one-third of SPs (O'Hara, 1978). Most patients treated conservatively (e.g., chest tube suction) will have a recurrence within one year (Voge & Anthracite, 1986).

Several personal variables have also been found to affect the likelihood of SP recurrence. Smokers are about 10 times more likely to develop SP relative to non-smokers (Bense, et al., 1985). In addition, incidents of SP are greater in males than females, due largely to their increased height, causing greater traction on apical blebs (Melton, et al., 1981).

Patients suffering from SPs often delay in seeking treatment. Greater than 50% of those with even moderate to severe symptoms often delay seeking treatment for hours or days (Voge & Anthracite, 1986). This behavior, similar to that commonly observed in patients who suffer heart attacks, suggests that an officer suffering an SP may remain on duty despite impairment, thereby increasing the likelihood of being involved in a critical, physically demanding incident while suffering from an SP. (Note: there is no association between exercise and recurrence of SP.)

b. RECOMMENDED EVALUATION PROTOCOL:

Medical records should be reviewed and the date and subsequent treatment of each SP should be documented.

In general, candidates should be restricted from field duties if they have had an SP within the last year that was treated conservatively. However, the physician should consider the number of SPs experienced by the candidate in the past, as well as the individual's smoking history and height, before making the final recommendation.

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